

adds very considerably to the teaching resources of the institution. Steps are being taken for its immediate enlargement.

The advances made in the recent past by the photographic art suggested that the biological school should not only have a place provided where it could take advantage of the help there afforded in illustration, but where photography, as applied to scientific work, could be taught.

During the past season the results in this direction have amply confirmed the opinion as to the value of photography in botany, both for reproducing microscopic appearances and for the larger visions of field work.

---

#### Development of cork-wings on certain trees. IV.

EMILY L. GREGORY.

##### *Physiology.*

The question of function can only be raised here, in case this peculiarity of structure is sufficiently emphatic to render it probable that some special object is to be gained from it. Assuming this to be true, the difference in the morphology of the three kinds described suggests a corresponding difference in function. In connection with this, two important principles held by scientists of the present day are to be considered. First, that no peculiarity of structure in living organisms is supposed to exist without adequate cause. For example, the wings of *Euonymus alatus*, which appear to the ordinary observer as useless if not cumbersome appendages, may be accounted for as a result of an effort on the part of its ancestors to accommodate themselves to their environment. According to this, it is not necessary, however, to show that an organ which proved advantageous to the ancestors of this plant is of equal service now to the offspring, unless it can be shown that the circumstances which called it into existence are still unchanged.

The second principle is that nature is extremely sparing of material; that of all the various means made use of to attain an end, those requiring the least outlay of material are the ones retained, and peculiarities of structure arising in harmony with this principle are the ones transmitted by inheritance.

Assuming the validity of these two principles, it would seem a proper question to ask: Of what use to these plants

are these corky outgrowths, and is the advantage secured commensurate with the outlay of the material? It is not claimed, however, that the results of the present investigations are such as to render possible a satisfactory answer to these questions. It is hoped that the few thoughts which have suggested themselves in this connection may be of some slight value.

The earlier researches made on the subject of cork seem to have fixed its use in the plant economy, as that of protection, mainly in the way of a substitute for epidermal tissue. This certainly is the office of periderm, both superficial and internal. Later investigations have somewhat broadened the meaning of the word; cork tissue has been defined,<sup>1</sup> "Not simply the tissue produced by cork cambium, but all parenchymatic cells which produce resin and which have a corky membrane, in general every cell which has a corky membrane." Accepting this definition, we must include as part of its function the repairing of tissues torn or broken by external or internal causes and aiding in the regulation of gases and transpiration.

We have already referred to Höhnel's division into phelloid and real cork-cells; to the former he gives two functions—first, to separate the bark from the stem, "Trennungsphelloid;" second, to take the place of the real cork, "Ersatzphelloid." According to the strict definition of bark, the first function can not be ascribed to the phelloid of the wing, nor, in fact, to that of any found in the superficial periderm. The second function means nothing unless we are able to decide what use the real cork would be to the stem if occurring in the same place.

Sections of the various kinds of wings were subjected to the usual tests for suberin, with varying results in the same species and sometimes even in sections cut from different places in the same plant.

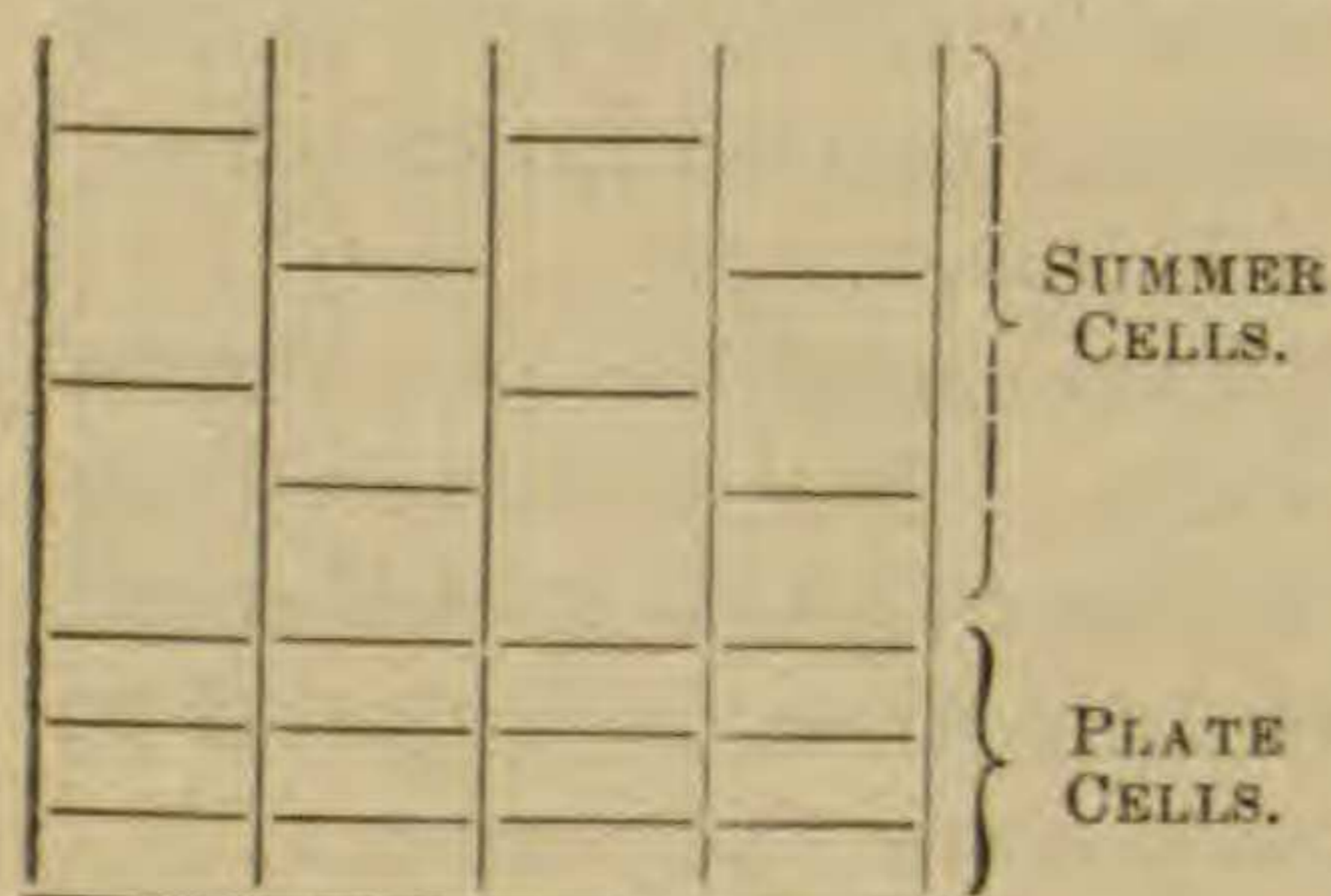
Sections of Liquidambar thoroughly heated in Schulze's macerating fluid and then treated with chlor-iodide of zinc, showed the following results: In no single case did all the summer cells show the pure ligneous reaction. The walls of some of these cells contained more or less suberin. In three or four experiments in which a large number of specimens were treated, the greater number of these cells were ligneous. Especially was this the case with the early summer cells of each year. This indicates that these cells are not lignified, if at all, until they reach some distance from the phellogen layer. The plate cells always showed the

<sup>1</sup>By E. Adlerz. See abstract in Just's Jahresbericht, XI (1883). 525.

suberin reaction. Several cases showed no inclination to the ligneous reaction; summer, as well as plate cells, appearing to be true cork, except along the edges where the break occurred. All along these edges the walls of the exposed cells and those lying next to them were colored a bluish purple, the color diminishing gradually in intensity toward the central portion of the wing. This is a noticeable and significant fact. In almost every specimen tested the outer edges were not suberized. This was not due to careless testing, as might be supposed, only enough of the chlor-iodide of zinc being used to affect the edges, for the sections were treated freely with this without a cover glass, and the reagent was dropped carefully on the center of the wing before it was allowed to reach the edges. The summing up of five or six sets of experiments is as follows: the tendency is for the summer growth to form ligneous walls, plate cells always cork.

In *Quercus* the results were very similar. A few specimens showed no ligneous tissue, several only at the edges along the lines of fracture, and still others gave a pure ligneous reaction throughout the entire summer cork. The same may be said of *Acer campestre*.

In *Acer monspessulanum* the results were the same, except here there were always ligneous cells along the line of breakage. *Euonymus alatus* differed from the preceding only in that the tendency to ligneous cells in the summer growth was more marked. A few words in passing here with reference to the morphology of these cells. In all examples studied, in case of the summer cells, the radial walls were met by the tangential ones about in the center of the cell, while in the plate cells the tangential walls were so cut off from each phellogen cell as to meet each other, thus forming a continuous line around the circumference. (See diagram.) This construction of the summer cells is mentioned



by Gerber<sup>2</sup> in reference to the outer cork layers of certain trees, which layers are stretched by the growth of the wood and phloem tissues inside. In the case he cites, this construction is accounted for on the ground of its allowing this stretching in the direction of the circumference, the radial walls

bending so as to form a zigzag line when looked at from a

<sup>2</sup>A. Gerber, Die jährliche Korkbildung im Oberflächenperiderm einige Bäume. Sitz. Bericht der Naturf. Ges. zu Halle, Jan. 12, 1888.

cross-section. This line, according to Gerber, indicates the degree of tension produced by the pressure of the new cells growing within the zone of cork cells. Now, the significant fact in connection with this in the cork wing is, there is no such tension from pressure of the growth within, because the constant breaking of tissue from the outside prevents it. The cells, which are arranged for this purpose, keep their rectangular form. The plate cells of the fall growth, which form a connected zone about the stem in *Quercus* and *Acer* and in *Liquidambar* connect with the regular periderm of the rest of the stem, have not this contrivance for stretching, and it may be supposed are more easily broken by the pressure within when the sudden and vigorous growth of spring begins. On the other hand, it was found that in the majority of specimens the walls of the plate cells were decidedly thicker than those of the summer cells, and in nearly all cases both radial and tangential walls were bent and curved.

In the formation of the wings of *Quercus* and *Acer* and others of a similar type, the first steps in the process are easily explained on the score of purely physical causes. The breaking of the tissues is the result of the strain, greater here than in other places, on the fresh yielding tissues. The increased rapidity of growth following this breakage is not unlike that caused by a wound external. Very soon, however, in *Acer* there is a change in the place of growth; that portion exposed by breakage to the more free action of the air is soon built out, so that many layers of cells occur between the phellogen and the external portion. (See *a* in fig. 3.) No reason suggests itself for the change in the place of rapid growing to the center of the wing, except the one which may be used when all others fail, namely, inherited tendency in this species. With *Quercus* this change of base in growth either does not occur or is much more gradual. As to the question of possible or probable advantage to the plant in these two examples, a few words on the function of lenticels are necessary.

In general they are held to be to the superficial periderm what the stomata are to the epidermis. Notwithstanding the thorough investigations made of these organs at different times, there still appears to be some question in regard to their exact mode of action in all cases where they occur.

Haberlandt<sup>3</sup> says that in case of green stems without per-

<sup>3</sup>G. Haberlandt, Beiträge zur Kenntniss der Lenticellen. Sitz. berichte der k. Akad. der Wiss. in Wien. Bd. 72. 1875.

iderm, when lenticels occur, they serve to hinder transpiration, on stems with periderm they increase it. Zahlbruckner<sup>4</sup> says, in winter they are permeable for air only in slight degree, in spring they are fully open, that is, in a condition to allow exchange of gases freely before the leaves have reached their growth. Klebahn<sup>5</sup> says, a winter closing of the lenticels does not exist, and that their permeability for gases in certain plants is the same both in summer and winter, in others, greater in the early part of summer.

One glance at the anatomy of the wing of *Quercus macrocarpa* and of *Acer* will suggest the possible connection here. The lenticels are raised by the rapidly-growing wings until they are separated entirely from the cells within the phellogen layer which they are supposed to furnish with air. Finally the outer cells break in regular lines along the corners of the stem, and during the first year, all along these broken places, free communication between the phellogen cells and the outer air is hindered only by the thin cellulose walls of one or two layers of cells. We say cellulose; we have proven that these walls are in no case suberized; they may be slightly lignified, but even in this case would offer less resistance to the interchange of gases than the suberized upper wall of the epidermis.

We then have the furrow between the wings acting as a continuous lenticel, in a less degree permeable, but still rendering an interchange of gases possible. Now as winter approaches this furrow is closed, in every case, by a few layers of real cork cells whose walls are suberized. In the spring this zone of cells is broken, the same conditions are renewed as in the preceding summer, as regards interchange of gases.

The probability that these furrows serve the plant in this way is increased in the case of *Quercus* by comparing its superficial periderm with that of *Quercus suber*. In the latter, the presence of the large and numerous lenticels, extending from the phellogen layer nearly to the surface of the thick periderm, and communicating there with the external air by means of shallow cracks along the surface, shows conclusively that the inner portions of the stem need to be in communication with the outside air. These lenticels are entirely wanting on the stems of *Quercus macrocarpa*. De Bary<sup>6</sup> states that lenticels lie in the furrows of the wings of *Acer campestre*, *Euonymus Europæus*, *Ulmus* and *Liquid-*

<sup>4</sup>Abstract in Just's Jahresb. XII. (1884) part 1, p. 265.

<sup>5</sup>H. Klebahn. Jenaische Zeitschrift für Naturwissenschaft, 1884, p. 588.

<sup>6</sup>Anatomy of Phanerogams and Ferns, p. 562.

ambar. This passage is given in explaining a sort of converse to the usual form of lenticels, that is, convex externally.

I have been unable to harmonize this statement with the examinations made. In no stems of *Acer campestre* under three years of age were any lenticels discovered between the wings; in fact, the anatomy given of the first and second year's growth seems to preclude the idea of lenticels forming in this position. If occurring in this place, in any of the stems available for examination, it must have been on stems so far advanced in age as to have lost the peculiar winged appearance. Such stems were not examined. It is still more difficult to understand the meaning of this passage in case of *Liquidambar* and *Euonymus Europæus*. There is here no question about the position of the lenticels. As already explained in the anatomy, the wings of *Liquidambar* occur, at first, as a single ridge, under a row of lenticels on the upper side of the stem, which afterward splits open along the line of opening of the lenticels, in many cases the break extending quite to the phellogen cells. During this growth there is a large portion of the circumference of the stem not affected by the wing formation; over this are scattered the convex lenticels, which are in no way different from those on stems without cork. None were discovered between the wings in any other sense than this, and there are certainly no exceptions to the usual convex lenticels.

In *Euonymus Europæus*, the wings are at the corners of the stem, and between them are broad spaces covered with epidermis, which is plentifully supplied with stomata. These soon pass from that stage into that of corky excrescences, which, examined after they are considerably developed, appear to consist of the same tissues as the wing.

*Biological Dept. Univ. of Penn.*

---

### The "King-Devil."

LESTER F. WARD.

On the 24th of August, 1879, as I was returning from a hunting excursion of two weeks in the "North Woods" which flank the Adirondack mountains on the west (my own game having been entirely of a vegetable nature), to Evans'